Is the Functional Reach Test Useful for Identifying Falls Risk Among Individuals With Parkinson’s Disease?

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Objective: To evaluate the effectiveness and validity of the Functional Reach Test (FRT) as a screening tool to identify fallers (persons at risk for falls) among subjects with Parkinson’s disease (PD) and control subjects.

Design: A case-comparison design with a consecutive sample. Subjects performed 3 consecutive functional reach trials.

Setting: Motor behavior laboratory in a university setting.

Participants: Fifty-eight adults (43 subjects with PD, 15 control subjects). Controls were recruited from a Florida hospital and the local community.

Interventions: Not applicable.

Main Outcome Measures: A falls history was recorded, a mean FRT score attained, and FRT scores were categorized as less than 25.4 cm, the criterion for falls risk, or ≥25.4 cm.

Results: Mean FRT scores differentiated subjects with PD and a known history of falls from subjects with PD and no history of falls and from control subjects (P < .001). Tests of validity for the FRT as a screening tool indicated sensitivity as 30%, specificity as 92%, positive predictive value as 90%, and negative predictive value as 36%.

Conclusions: The FRT, using a reach less than 25.4 cm as a criterion for falls risk, is not a sensitive instrument for identifying individuals with PD at risk. However, the percentage of those persons identified as at risk by the FRT are highly likely at risk, and they should be referred for falls risk intervention. Because the FRT does not identify every person at risk, using a test battery addressing other factors contributing to falls risk may increase the sensitivity of a clinician’s assessment to identify persons with PD at risk for falls.

Key Words: Evaluation; Falls, accidental; Parkinson disease; Rehabilitation. © 2002 by the American Congress of Rehabilitation Medicine and the American Academy of Physical Medicine and Rehabilitation
the battery of tests for evaluation of balance dysfunction in specific patient populations. By identifying individuals with PD at risk for falls, clinicians may appropriately direct resources such as patient education and therapy for falls prevention to reduce risk and injury.

The purpose of this study was 3-fold: to assess (1) whether the FRT could identify those who are at risk for falls among individuals with PD, (2) whether 1 trial only or the mean of 3 consecutive test trials better identifies fallers among individuals with PD, and (3) the validity of the FRT as a screening tool for falls risk and risk intervention using a reach less than 25.4 cm as the criterion in persons with PD.

METHODS

Participants

Before undergoing pallidotomy surgery, 43 adults with idiopathic PD participated in this study. Subjects were asked if they had experienced 1 or more falls in the past 6 months. A fall was defined as an incident that resulted in the person unexpectedly coming to the ground. A faller was defined as a person who had experienced 1 or more falls in the 6-month period immediately before the study. Depending on their response, subjects with PD were categorized into the following 2 groups: those with a history of falls or those with no history of falls. The adults with PD remained on their regular medication schedule throughout testing. The first 15 elders without PD and no history of falls and who met the study criteria served as controls and were selected from a group of 25 volunteers recruited from community civic organizations, University of Florida faculty, health fairs in the local mall, and retirement centers. Before the evaluation, each subject reviewed and signed an informed consent form approved by the institutional review board. To be included in the study, subjects were required to be medically stable without any other neurologic or orthopedic disorder and to score 24 or greater on the Folstein Mini-Mental State Exam. Subjects with PD were also evaluated by using the Hoehn and Yahr disability scale. Subjects scoring stage 5 on the Hoehn and Yahr were not included.

Procedure

The FRT was administered according to the procedure described by Duncan et al. After the examiner explained and showed the FRT, each subject performed 1 practice trial and 3 test trials. Functional reach was measured by using a leveled yardstick attached to the wall at the height of the subject’s right acromion. To measure the subject’s reaching distance, an examiner stood 4 feet away from the yardstick and recorded the initial and end reach positions. Subjects stood comfortably with feet approximately shoulder-width apart, made a loose fist, and, without touching the wall, placed the right arm parallel to the yardstick (initial position). Subjects then reached as far forward as they could without losing their balance (end position). The position of the third metacarpal along the yardstick was recorded at both the initial and end positions. Subjects were allowed to balance on their toes; however, touching the wall, stepping while reaching forward, or holding onto their clothing with the left hand invalidated the trial. If invalidated, the trial was repeated with a maximum of 5 test trials to achieve 3 valid trials. All subjects were guarded during the test. The mean difference between the initial position and the end position for the 3 test trials was calculated as the functional reach.

Data Analysis

By using 1-way analysis of variance (ANOVA) comparisons, we analyzed descriptive characteristics indicating age, disease duration, gender, Hoehn and Yahr score, and history of falls for the following 3 groups: (1) PD and falls history, (2) PD and no falls, and (3) controls. The functional reach measures for the 3 groups were compared by using a 1-way ANOVA first with the mean of 3 FRT trials as the dependent variable and then by using only the score from the first FRT trial as the dependent variable.

The distance reached was further classified into 2 categories, according to distance and falls risk criterion for each group. The categories were: A, reach less than 25.4 cm, and B, reach $\geq 25.4$ cm. Frequency distributions for each category were determined. The validity of the FRT as a screening tool to identify individuals at risk for falls was analyzed by comparing test outcomes for category A reaches (positive test for falls risk) with category B reaches (negative test for falls risk) with the subject’s reported history of falls. The following measures of validity were performed: (1) test sensitivity, the ability of the FRT to obtain a positive test when the condition, history of falls, is truly present; (2) test specificity, the ability of the FRT to obtain a negative test when the condition, history of falls, is absent; (3) positive predictive value, an estimate of the probability that a person who tests positive for falls risk actually has a history of falls; and (4) negative predictive value, the probability that a person who tests negative on the FRT actually does not have a history of falls.

RESULTS

Subject Characteristics

The descriptive data for the subjects in this study are presented in table 1. Forty-three adults with idiopathic PD and a mean age $\pm$ standard deviation (SD) of 64.3 $\pm$ 9.3 years participated in this study. Thirty of these adults reported a positive history of falls (mean age, 65.2 $\pm$ 7.4 years) and 13 adults (mean age, 57.2 $\pm$ 8.9 years) reported no history of falls. The mean age for the group of 15 adults in the control group was 68.6 $\pm$ 10.1 years. A 1-way ANOVA and Scheffé post hoc comparisons of the mean age by group revealed that the group with PD and no history of falls was statistically younger than both the healthy older adults and the group with PD and a history of falls. The healthy older adults and the group with PD and a positive falls history were not significantly different in age. All subjects resided in the community and could ambulate at the household level, and the subjects with PD had a Hoehn and Yahr score of 3 or 4. For all subjects with PD, the average length of disease duration was 12.4 $\pm$ 5.1 years.

<table>
<thead>
<tr>
<th>Table 1: Descriptive Characteristics of the 3 Test Groups</th>
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<tbody>
<tr>
<td><strong>Groups</strong></td>
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<tr>
<td><strong>Age (y)</strong></td>
</tr>
<tr>
<td>Range</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
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<tr>
<td>Men</td>
</tr>
<tr>
<td>Women</td>
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<tr>
<td><strong>Disease duration (y)</strong></td>
</tr>
<tr>
<td>Range</td>
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years (range, 5–24y; note: 4 missing data points). The subjects with a falls history had a mean disease duration of 12.6 ± 5.5 years (range, 5–24y), and the subjects with no history of falls had a mean disease duration of 10.9 ± 3.5 years (range, 5–17y). The length of disease duration was not significantly different between these 2 groups. Thirty-four men and 24 women participated in the study. Twenty-five men and 18 women comprised the group with PD: 15 men and 15 women were in the group with a history of falls, whereas 10 men and 3 women were in the group with no history of falls. Nine men and 6 women formed the control group.

**Functional Reach Measures**

**Group comparisons.** No subject required more than 4 functional reach trials to achieve 3 valid test trials. First, a 1-way ANOVA comparison of the functional reach measures (using the mean of 3 test trials) by group determined significant differences ($F_{2,55} = 7.869, P = .001$). A Student-Newman-Keuls post hoc comparison accounting for unequal sample sizes revealed significant differences in mean FRT scores between the group with PD and a history of falls (mean, 27.5 ± 8.5cm) and the healthy adult group (mean, 36.4 ± 7.0cm) and between the group with PD and a history of falls and the group with PD and no history of falls (mean, 33.4 ± 4.9cm) (fig 1).

Second, we compared group performance by using only the first trial of the FRT with a 1-way ANOVA. Significant differences among the groups were found ($F_{2,55} = 8.37, P = .0007$). Specifically, Student-Newman-Keuls post hoc comparisons showed differences between the group with PD and a history of falls (mean, 26.6 ± 8.9cm) and the control group (36.5 ± 7.5cm) as well as between the group with PD and no history of falls (mean, 32.5 ± 5.2cm).

**Test validity.** The distance reached (obtained by using the mean of 3 test trials) was further classified into 2 categories according to distance and falls risk1 for each group. The categories were A, reach less than 25.4cm, and B, reach ≥25.4cm (fig 2). The validity of the FRT as a screening tool for identifying persons with PD at risk for falls was evaluated by recording the ability of the FRT falls criterion (reach <25.4cm) to identify accurately persons with a known history of falls (table 2).12 Test sensitivity, the ability of the FRT to obtain a positive identification of falls risk (reach <25.4cm) when the condition history of falls was truly present, was 30%. Positive identifications of persons with PD and a known history of falls were thus not readily determined by the FRT. Test specificity, the ability of the FRT to obtain a negative test (reach ≥25.4cm) when the condition history of falls was absent, was 92%. This high percentage indicates that the individual with PD and a reach ≥25.4cm was less likely to have a history of falls. The positive predictive value, an estimate of the probability that a person who tests positive on the FRT actually has a history of falls, was 90%. This value indicates that 90% of those subjects who tested positive for falls risk actually had a history of falls. Such individuals would be immediately recommended for falls risk intervention. The negative predictive value, the probability that a person who tests negative on the FRT risk criterion (reach ≥25.4cm) actually does not have a history of falls, was 36%.17

**DISCUSSION**

Our findings indicate that the FRT, using either the mean of 3 consecutive test trials or only the initial test trial, effectively differentiated (1) subjects with PD having a history of falls from subjects with PD and no history of falls and (2) subjects with PD having a history of falls from healthy adults. Smithson et al16 found functional reach scores that are relatively similar to our findings among 3 identical subject groups. They reported mean functional reach scores of 34.20 ± 4.12cm for the control group, 29.95 ± 3.82cm for the subjects with PD who had no

![Fig 1. Mean and SD for FRT performance (mean of 3 consecutive trials) for group with PD and a history of falls (PD + Falls), with PD and no history of falls (PD – Falls), and the control group.](image1)

![Fig 2. Percentage of subjects with reach less than 25.4cm and percentage of subjects with reach ≥25.4cm in a group with PD and a history of falls (PD + Falls), a group with PD and no history of falls (PD – Falls), and a control group.](image2)

**Table 2: Sensitivity, Specificity, Positive Predictive Value, and Negative Predictive Value for the FRT for Identifying Falls Risk in Persons With PD**

<table>
<thead>
<tr>
<th>Screening Test</th>
<th>Falls History in Individuals With PD</th>
<th>Total</th>
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<tbody>
<tr>
<td></td>
<td>Hx of Falls (†)</td>
<td>No Falls Hx (‖)</td>
</tr>
<tr>
<td>Reach &lt;25.4</td>
<td>9*</td>
<td>1†</td>
</tr>
<tr>
<td>(+ falls risk)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reach ≥25.4</td>
<td>21‡</td>
<td>12*</td>
</tr>
<tr>
<td>(– falls risk)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>13</td>
</tr>
</tbody>
</table>

NOTE. Based on frequency of reaches less than 25.4cm and reaches ≥25.4cm in a group with a history of falls and a group with no history of falls. A reach less than 25.4cm was the falls risk criterion, compared with the criterion standard of a reported history of falls in persons with PD. Sensitivity = a/(a + c) = 30%, specificity = d/(b + d) = 92%, positive predictive value = a/(a + b) = 90%, and negative predictive value = d/(c + d) = 36%.

ABBREVIATION: Hx, history.

* True positives, persons with a history of falls correctly identified as at risk.
† False positives, persons incorrectly identified as at risk for falls.
‡ False negatives, persons who are incorrectly identified as not at risk for falls.
§ True negatives, persons with no history of falls correctly identified as not at risk.
history of falls; and 24.45 ± 5.93 cm for the PD group who had a history of falls. These researchers modified the FRT by using only 1 trial as compared with the 3 trials described by Duncan et al. In our study, subjects practiced the reach 1 time before performing the 3 test trials. This practice trial provided increased familiarity with the FRT task that may have improved performance and account for the relatively greater scores reported in our study for the 1 trial only and mean of 3 test trials results. These findings, like those of Smithson, show that the FRT differentiates between faller and nonfaller groups using only 1 trial of functional reach. Clinicians may thus consider using only 1 trial to evaluate effectively the functional reach performance of a person with PD, which would be a time saver for a clinician screening the patient. However, clinicians are encouraged to cautiously interpret findings among studies that have followed different testing protocols for the FRT when translating results to practical applications.

Although the group with PD and no history of falls was younger than both the group with PD and a history of falls and the control group, the groups with PD were comparable based on the mean disease duration, level of disability, and severity of disease progression such that additional medical treatment was sought. Subjects entered this study as a sample of convenience with no inclusion or exclusion criteria based on age. Differences in group behavior relative to falls risk may be a factor of age at onset of disease regardless of disease duration, disease progression, or an interaction of these elements.

Validity of the FRT is supported by specificity results. Test specificity for the FRT indicated that 92% of all persons with PD tested truly had no history of falls were also identified by the FRT outcome as having a negative falls risk (reach ≥ 25.4 cm). In addition, a high, positive predictive value of 90% provides a strong probability that the persons tested and showing a positive falls risk (reach < 25.4 cm) also actually have a positive history for falls. Clinicians who have identified individuals with PD at risk for falls by using the FRT may with greater certainty appropriately begin patient and family education and falls risk intervention or refer these patients to receive the appropriate services.

In contrast, validity of the FRT is not well supported by the sensitivity results. Only 30% of all the individuals having a history of falls were identified as at risk by using the FRT and the falls risk criterion of reach less than 25.4 cm. The ability to obtain a positive FRT for falls risk (reach < 25.4 cm) when the condition history of falls is truly present in a person with PD is weak. Thus, some persons who are at risk for falls were missed when using the FRT as a screening tool. Additionally, the negative predictive value, the probability that a person who tests negative (reach ≥ 25.4 cm) relative to the FRT risk criterion (reach < 25.4 cm) actually does not have a history of falls, was 36%. This relatively low percentage means that persons with PD identified as not being at risk for falls based on the functional reach risk criterion may in fact still be at risk for falls.

The criterion reach for falls risk used in this study of persons with PD was based on a criterion established in a prospective study of elderly, community-dwelling male veterans, aged 74 to 104 years, who experienced chronic recurring falls. In selecting a criterion for screening falls risk, one must consider the consequences of an incorrect cutoff score. Hypothetically, if the criterion for falls risk was set to a value higher than the current criterion (25.4 cm), more individuals with PD who are not truly at risk for falls (false positives) may be referred for falls risk intervention and treatment. In contrast, if the criterion is too low, persons who are at risk may not be correctly identified as being at risk (false negatives). Such persons would likely not be referred for falls risk intervention and may subsequently experience a fall and injury. To decrease the number of false negatives and successfully screen more persons with PD at risk for falls, the threshold criterion for functional reach could be increased.

Reviewing our data and using a hypothetical 5.1 cm increase in the falls risk threshold (30.1 cm), 8 additional subjects with PD and a history of falls would be identified as at risk (true positives) and 2 additional subjects with PD and no history of falls would be identified as at risk (false positives). Sensitivity of the FRT for identifying persons with PD and a history of falls as at risk (true positives) would consequently increase from 30% to 56%, and test specificity would decrease from 90% to 77%. Thus, 44% of the subjects with PD and a history of falls would not have been identified as at risk for falls. When assessing the population with PD, increasing the reach criterion for falls risk would increase test sensitivity and likely be worth the trade-off effect on test specificity. The potential risks for falls and injury by persons that truly are at risk for falls (and who are not identified as being at risk) should direct criterion changes that may improve the test validity of the FRT. Future studies should investigate alternative criteria for falls risk in the population with PD.

The FRT measures an individual’s ability to maintain AP stability during a forward reach task while maintaining a stable base of support in standing. The FRT is not the definitive test of balance, but simply tests one dimension of balance. Other factors may possibly effect FRT performance, such as ROM limitations at the ankle, trunk, hip, or shoulder joints. It is unlikely that a falls risk assessment can be accomplished for any population with a single evaluative instrument. Many other mechanisms certainly contribute to balance dysfunction and the occurrence of falls in concert with the progression of PD. Increased attentional demands, diminished ability to perform dual activities while walking, and freezing or the sudden cessation of walking occur with progressing PD and potentially impair balance. Additionally, factors not related to PD also affect falls risk, including the home environment, sensory changes, weakness, and ROM. Consequently, a battery of tests to identify problems associated with falls risk for individuals with PD appears necessary. The nature of PD, its primary and secondary impairments, the disease progression, and the complexity of factors contributing to falls risk make the clinical use of a single screening instrument for falls risk unlikely. Alternatively, additional screening tests are suggested to address and evaluate other valid factors contributing to falls risk.

CONCLUSION

The FRT effectively differentiated (1) subjects with PD having a history of falls from subjects with PD and no history of falls and (2) subjects with PD having a history of falls from healthy adults. A functional reach criterion of less than 25.4 cm for risk of falls identified only 30% of the individuals with PD known to be at risk from their history of falls. This degree of test sensitivity is not acceptable when clinical decisions, referrals for intervention, and patient safety are based on the outcomes of a screening test. An increase in the reach criterion to 30.1 cm for falls risk nearly doubled the test sensitivity of the FRT, although 44% of the persons at risk remained unidentified by the FRT. By using a battery of tests to evaluate the multiple factors associated with falls risk may increase the overall sensitivity of a clinician’s assessment to identify persons with PD at risk for falls.

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References